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(54) REAR PROJECTION SCREEN

(57) A rear projection screen has a lens sheet or optical sheet which have an optical function such as light condensation, light diffusion. The lens sheet or the optical sheet has at least two diffusion layers (diffusion portions) which are spaced from each other in a light transmitting direction as a whole. It is preferable to provide one of the diffusion layers on the surface on the light entering side of the lens sheet or the optical sheet which is provided at the position nearest to the light source and the other diffusion layer on the surface on the light exiting side of the lens sheet or the optical sheet which is provided at the position nearest to the observation side. Further, it is preferable that, among the two diffusion layers, the one near the light source side has a smaller light diffusion degree than the one near the observation side. Further, it is preferable to add different (in refractive index or in average particle diameter) diffusion agents to the diffusion layer near the light source side and the diffusion layer near the observation side.

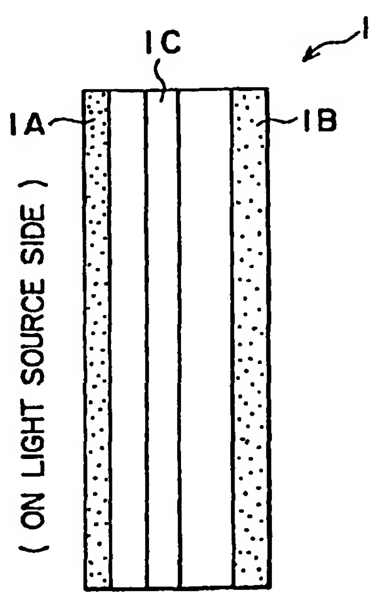

FIG. I

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an illustration showing a first embodiment of a rear projection screen according to the present invention.

Fig. 2 is an illustration showing a second embodiment of a rear projection screen according to the present invention.

Fig. 3 is an illustration showing a rear projection screen of Example 1 according to the present invention.

Fig. 4 is an illustration showing a rear projection screen of Example 2 according to the present invention.

Fig. 5 is an illustration showing a rear projection screen of Example 3 according to the present invention.

Fig. 6 is an illustration showing a rear projection screen of Example 4 according to the present invention.

Fig. 7 is an illustration showing a rear projection screen of Example 5 according to the present invention.

Fig. 8 is an illustration showing a rear projection screen of Example 6 according to the present invention.

Figs. 9A and 9B are illustrations showing rear projection screens of Example 7 according to the present invention.

Fig. 10 is an illustration showing a comparative rear projection screen.

BEST MODE FOR CARRYING OUT THE INVENTION

By referring now to the accompanying drawings, embodiments of the present invention will be described below.

First Embodiment

Fig. 1 is an illustration showing a first embodiment of a rear projection screen according to the present invention.

As shown in Fig. 1, a rear projection screen 1 is composed of a single lens sheet having on one surface or both surfaces thereof a Fresnel lens or lenticular lenses, wherein two or more diffusing parts 1A, 1B are provided separately in the light-transmitting direction (in the direction of the left and right sides in the figure). In this first embodiment, the diffusing parts 1A and 1B are provided on the light-entering-side surface (light-entering surface) and light-emerging-side surface (light-emerging surface) of the lens sheet, respectively.

The diffusing parts 1A, 1B are parts for diffusing light, and can readily be formed by a conventional method, for example, by using a resin layer containing a diffuser (diffusive fine particles) such as microlenses, glass beads or organic beads, or by embossing the surfaces of microlenses.

It is noted that the diffusing parts can be provided not only on the surfaces of the lens sheet but also inside the lens sheet like a diffusing part 1C.

The diffusing parts 1A, 1B diffuse light emitted from a light source to destroy the coherence of the light, so that they can solve the problem of scintillation or speckle. However, when light from a light source is diffused, the resolution is lowered. Further, when a large amount of a diffuser is incorporated into one diffusing part as in the conventional method, the gain is decreased, and the image thus becomes very dark.

According to the first embodiment of the present invention, since the two diffusing parts 1A and 1B are separately provided on the lens sheet, it is possible to make the intensity of scintillation or the like low by using a diffuser in an amount smaller than that of a diffuser which is required for a lens sheet having only one diffusing part to attain the equally low intensity of scintillation or the like. Moreover, since the amount of the diffuser used is small, the lowering of the gain is prevented, and the brightness of the image can thus be prevented from being unfavorably decreased.

Further, since the two diffusing parts 1A and 1B are separately provided on the lens sheet, it is enough to incorporate a decreased amount of a diffuser into one diffusing part. Therefore, the amount of stray light to be produced inside the diffusing parts 1A, 1B can be decreased, and the unfavorable lowering of resolution to be caused by flare, ghost or the like can thus be prevented.

Furthermore, by this light-diffusing effect, moires to be formed by the interference between Fresnel lenses, lenticular lenses, or pixels of a light source can be decreased.

It is preferable that the diffusing parts 1A and 1B be provided on the light-entering-side surface and light-emerging-side surface of the lens sheet, respectively. The reason for this is as follows. When the diffusing parts 1A and 1B are provided at the above-described positions, the distance between the two diffusing parts becomes long, so that light emitted from a light source cannot show coherence. Therefore, the intensity of scintillation or the like can be decreased, and the lowering of the brightness of the image can be minimized while controlling the light-diffusing effect at the diffusing parts 1A and 1B to extremely low.

Further, it is preferable that the diffusing power of the diffusing part 1A on the light source side be made lower than that of the diffusing part 1B on the observation side. By doing so, the degree of the diffusion of light which is caused on the light-entering side by diffusing elements becomes low. The intensity of scintillation or the like can thus be decreased while preventing the resolution from being unfavorably lowered.

Scintillation or the like can be evaluated not only by th- above-described intensity of scintillation or the like, but also by the magnitude (roughness) of scintillation or the like which is caused when a dynamic picture image is projected. In

face 11a by embossing a Fresnel lens part on the light-entering surface 11a. On the light-emerging surface 11b of the lens sheet 11 was formed the diffusing layer 10B having a thickness of 500 micrometers, in which 15 parts by weight of glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535 were dispersed. It is noted that, in this Example and also in the following Examples 2 to 7 and Comparative Example, the amount (parts by weight) of the diffuser such as glass beads is a value based on 100 parts by weight of the base material into which the diffuser is incorporated.

As the base material of the lens sheet 11, an impact-resistant methacrylic resin (refractive index 1.51) manufactured by Sumitomo Chemical Co., Ltd., Japan was used. As the glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535, "EMB20" manufactured by Toshiba-Ballotini Co., Ltd., Japan was used.

An image was projected on the thus-produced rear projection screen 10 by using an LCD projector, and observed for evaluation. As a result, it was confirmed that the intensity of scintillation caused on the image was low and that the resolution of the image was excellent.

Example 2

Fig. 4 is an illustration showing a rear projection screen of Example 2 according to the present invention. Example 2 corresponds to the second embodiment shown in Fig. 2, and, in this rear projection screen of Example 2, two diffusing layers (diffusing parts) are separately provided on two lens sheets, one diffusing part on one lens sheet. One of the two diffusing layers is provided on the surface of the lens sheet (the light-entering-surface of a Fresnel lens sheet).

Namely, in this Example, a rear projection screen 20 was produced, as shown in Fig. 4, by the combination use of a Fresnel lens sheet 21 having a thickness of 2 mm, made from polymethyl methacrylate, and a lenticular lens sheet 22 having a thickness of 1 mm, made from polymethyl methacrylate. On the light-entering surface 21a of the Fresnel lens sheet 21 was formed a diffusing layer 20A having a thickness of 150 micrometers, in which 7.0 parts by weight of organic beads (cross-linked polymer beads) having an average particle diameter of 12 micrometers and a refractive index of 1.59 were dispersed. Further, into the lenticular lens sheet 22 (diffusing layer 20B) were homogeneously incorporated 0.75 parts by weight of organic beads having an average particle diameter of 12 micrometers and a refractive index of 1.59.

As the base material of the Fresnel lens sheet 21 and that of the lenticular lens sheet 22, an impact-resistant methacrylic resin (refractive index 1.51) manufactured by Sumitomo Chemical Co., Ltd., Japan was used. As the organic beads having an average particle diameter of 12 micrometers and a refractive index of 1.59, "PB3011" (styrene beads) manufactured by Sumitomo Chemical Co., Ltd., Japan was used.

An image was projected on the thus-produced rear projection screen 20 by using an LCD projector, and observed for evaluation. As a result, it was confirmed that the intensity of scintillation caused on the image was low and that the resolution of the image was excellent.

Example 3

Fig. 5 is an illustration showing a rear projection screen of Example 3 according to the present invention. Example 3 corresponds to the second embodiment shown in Fig. 2, and, in this rear projection screen of Example 3, two diffusing layers (diffusing parts) are separately provided on three lens/optical sheets. One of the two diffusing layers is provided on the surface of the outermost lens sheet on the light source side (the light-entering-surface of a Fresnel lens sheet), and the other diffusing layer is provided on the surface of the outermost optical sheet on the observation side (the light-entering-surface of a flat face panel).

Namely, in this Example, a rear projection screen 30 was produced, as shown in Fig. 5, by the combination use of a Fresnel lens sheet 31 having a thickness of 2 mm, made from polymethyl methacrylate, a flat face panel 32 having a thickness of 2 mm, made from polymethyl methacrylate, and a lenticular lens sheet 33 having a thickness of 1 mm, made from polymethyl methacrylate, containing no diffuser, provided between the Fresnel lens sheet 31 and the flat face panel 32. On the light-entering surface 31a of the Fresnel lens sheet 31 was formed a diffusing layer 30A having a thickness of 150 micrometers, in which 45 parts by weight of glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535 were dispersed. On the light-entering surface 32a of the flat face panel 32 was formed a diffusing layer 30B having a thickness of 150 micrometers, in which 45 parts by weight of glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535 were dispersed.

As the base materials of the Fresnel lens sheet 31, of the flat face panel 32 and of the lenticular lens sheet 33, an impact-resistant methacrylic resin (refractive index 1.51) manufactured by Sumitomo Chemical Co., Ltd., Japan was used. As the glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535, "EMB20" manufactured by Toshiba-Ballotini Co., Ltd., Japan was used.

An image was projected on the thus-produced rear projection screen 30 by using an LCD projector, and observed for evaluation. As a result, it was confirmed that the intensity of scintillation caused on the image was low and that the

Example 6

Fig. 8 is an illustration showing a rear projection screen of Example 6 according to the present invention. Example 6 corresponds to the second embodiment shown in Fig. 2, and, in this rear projection screen of Example 6, three diffusing layers (diffusing parts) are separately provided on three lens/optical sheets, one diffusing layer on one lens or optical sheet. The three diffusing layers are respectively provided on the surfaces (the light-entering surfaces) of the three lens/optical sheets.

Namely, in this Example, a rear projection screen 60 was produced, as shown in Fig. 8, by the combination use of a Fresnel lens sheet 61 having a thickness of 2 mm, made from polymethyl methacrylate, a flat face panel having a thickness of 2 mm, made from polymethyl methacrylate, and a lenticular lens sheet 63 having a thickness of 1 mm, made from polymethyl methacrylate, provided between the Fresnel lens sheet 61 and the flat face panel 62. On the light-entering surface 61a of the Fresnel lens sheet 61 was formed a diffusing layer 60A having a thickness of 100 micrometers, in which 3.5 parts by weight of glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535 were dispersed. On the light-entering surface 62a of the flat face panel 62 was formed a diffusing layer 60B having a thickness of 100 micrometers, in which 3.5 parts by weight of glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535 were dispersed. On the light-entering surface 63a of the lenticular lens sheet 63 was formed a diffusing layer 60C having a thickness of 300 micrometers, in which 5.0 parts by weight of organic beads having an average particle diameter of 30 micrometers and a refractive index of 1.49 were dispersed.

As the base materials of the Fresnel lens sheet 61, of the flat face panel 62, and of the lenticular lens sheet 63, an impact-resistant methacrylic resin (refractive index 1.51) manufactured by Sumitomo Chemical Co., Ltd., Japan was used. As the glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535, "EMB20" manufactured by Toshiba-Ballotini Co., Ltd., Japan was used. Further, as the organic beads having an average particle diameter of 30 micrometers and a refractive index of 1.49, "XC01" (acrylic beads) manufactured by Sumitomo Chemical Co., Ltd., Japan was used.

An image was projected on the thus-produced rear projection screen 60 by using an LCD projector, and observed for evaluation. As a result, it was confirmed that the intensity of scintillation caused on the image was low and that the resolution of the image was excellent.

Example 7

Figs. 9A and 9B are illustrations showing rear projection screens of Example 7 according to the present invention. Example 7 corresponds to the second embodiment shown in Fig. 2, and, in these rear projection screens of Example 7, two diffusing layers (diffusing parts) are separately provided on two lens sheets. Further, the type (refractive index and average particle diameter) of the diffuser incorporated into the diffusing layer provided on the light source side is different from that of the diffuser incorporated into the diffusing layer provided on the observation side.

Namely, in this Example, rear projection screens 70, 80 were produced, as shown in Figs. 9A and 9B, by the combination use of Fresnel lens sheets 71, 81 made from polymethyl methacrylate, and lenticular lens sheets 72, 82 having a thickness of 1 mm, made from polymethyl methacrylate. As shown in Figs. 9A and 9B, the shape and structure of the rear projection screen 70 are identical with those of the rear projection screen 80 except that the structure of the Fresnel lens sheet 71 is different from that of the Fresnel lens sheet 81.

As the base material of the Fresnel lens sheets 71, 81, an impact-resistant methacrylic resin (refractive index 1.51) manufactured by Sumitomo Chemical Co., Ltd., Japan was used. This resin was subjected into extrusion molding, and a Fresnel lens part was formed on one surface of the molded product by coating thereto a UV-curable resin containing no diffuser, followed by curing the UV-curable resin by the application of ultraviolet rays, thereby obtaining the Fresnel lens sheets 71, 81. It is noted that the boundary between the substrate and the Fresnel lens part formed thereon by the use of the UV-curable resin is not shown in Figs. 9A and 9B.

The Fresnel lens sheet 71 shown in Fig. 9A is a lens sheet obtained by forming a Fresnel lens part on one surface of a single layer (diffusing layer 70A), serving as a substrate, into which a diffuser having a predetermined average particle diameter and refractive index is homogeneously incorporated. On the other hand, the Fresnel lens sheet 81 shown in Fig. 9B is a lens sheet obtained by forming a Fresnel lens part on one surface of a co-extruded two-layered substrate having, on the light-entering surface 81a thereof, a diffusing layer 80A in which a diffuser having a predetermined average particle diameter and refractive index is dispersed.

Into the diffusing layers 70A, 80A was incorporated, as the diffuser, one of (1) acrylic beads having an average particle diameter of 30 micrometers and a refractive index of 1.49 ("XC01" manufactured by Sumitomo Chemical Co., Ltd., Japan), (2) acrylic beads having an average particle diameter of 11 micrometers and a refractive index of 1.49 ("MBX" manufactured by Sekisui Chemical Co., Ltd., Japan), (3) glass beads having an average particle diameter of 17 micrometers and a refractive index of 1.535 ("EGB210" manufactured by Toshiba-Ballotini Co., Ltd., Japan), and (4) styrene

the thus-produced various rear projection screens 70, 80 by using an LCD projector, and evaluated in terms of the intensity and magnitude (roughness) of scintillation or the like caused on the images. The results obtained are as shown in the following Table 2. The magnitude (roughness) of scintillation or the like was evaluated by the roughness of speckle perceived by an observer when he/she moved his/her eyes. The intensity and magnitude (roughness) of scintillation or the like were evaluated according to 6 ranks of "5" (most excellent) to "0" (poorest).

ical Co., Ltd., Japan) as the diffuser to be incorporated into the Fresnel lens sheet (FL) on the light source side, and glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535 ("EMB20" manufactured by Toshiba-Ballotini Co., Ltd., Japan) as the diffuser to be incorporated into the lenticular lens sheet (LL) on the observation side show good results in terms of both the intensity and magnitude (roughness) of scintillation or the like.

Further, from the results shown in the above Table 2, the following tendency is confirmed: the intensity of the scintillation or the like becomes lower and the magnitude (roughness) of the same becomes smaller as the difference between the refractive index of the diffuser to be incorporated into the Fresnel lens sheet (FL) on the light source side and that (1.51) of the base material in which the diffuser is dispersed becomes smaller (for instance, compare the "MBX 1.8t" series results with the "PB3011 1.8t" series results, where the average particle diameter of "MBX" is almost equal to that of "PB3011"). Furthermore, it is also confirmed that the magnitude (roughness) of scintillation or the like becomes smaller as the average particle diameter of the diffuser incorporated into the lenticular lens sheet (LL) on the observation side becomes smaller (for instance, compare the "EGB" series results with the "EMB" series results, where the refractive index of "EGB" is equal to that of "EMB"). With respect to the average particle diameter of the diffuser to be incorporated into the lenticular lens sheet (LL), a great improvement is found in the magnitude (roughness) of scintillation between the average particle diameter of 17 micrometers ("EGB210") and that of 11 micrometers ("EMB20"), especially in the vicinity of the average particle diameter of 15 micrometers.

The following is also confirmed from the results shown in the above Table 2: the intensity of scintillation becomes lower and the magnitude (roughness) of the same becomes smaller as the thickness of the Fresnel lens sheet (FL) becomes greater, and when the Fresnel lens sheet is not composed of a single layer but composed of two layers.

<u>Comparative Example</u>

Fig. 10 is an illustration showing a comparative rear projection screen.

In this Comparative Example, a rear projection screen 70 was produced, as shown in Fig. 10, by the combination use of a Fresnel lens sheet 91 having a thickness of 2 mm, made from polymethyl methacrylate, containing no diffuser, and a lenticular lens sheet 92 having a thickness of 1 mm, made from polymethyl methacrylate. Into the lenticular lens sheet 72 (diffusing layer 90B), 5 parts by weight of glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535 were homogeneously incorporated.

As the base material of the Fresnel lens sheet 91, and that of the lenticular lens sheet 92, an impact-resistant methacrylic resin (refractive index 1.51) manufactured by Sumitomo Chemical Co., Ltd., Japan was used. As the glass beads having an average particle diameter of 11 micrometers and a refractive index of 1.535, "EMB20" manufactured by Toshiba-Ballotini Co., Ltd., Japan was used.

An image was projected on the thus-produced rear projection screen 90 by using an LCD projector, and observed for evaluation. As a result, it was confirmed that the intensity of scintillation caused on the image was high and that the quality of the image was poor.

According to the present invention, since at least two diffusing parts are separately provided on one lens sheet or optical sheet, or on a plurality of lens sheets or optical sheets, it is possible to make the intensity of scintillation low by using a diffuser in an amount smaller than that of a diffuser which is required for a lens sheet having only one diffusing part to attain the equally low intensity of scintillation. Further, by respectively incorporating diffusers of different types into two diffusing parts, not only the intensity of scintillation or the like can be made low, but also the magnitude (roughness) of the same can be made small. Scintillation or the like to be caused on an image can thus be effectively decreased without lowering the resolution and brightness of the image.

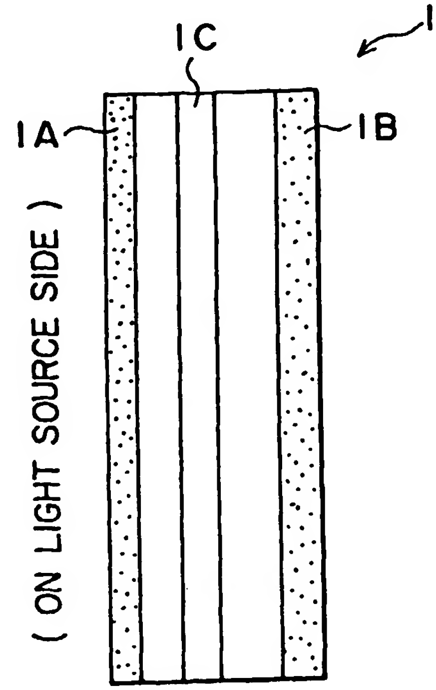
Claims

1. A rear projection screen comprising a lens sheet having an optical function of condensing or diffusing light, wherein the lens sheet has two or more diffusing parts separately provided in a light-transmitting direction.

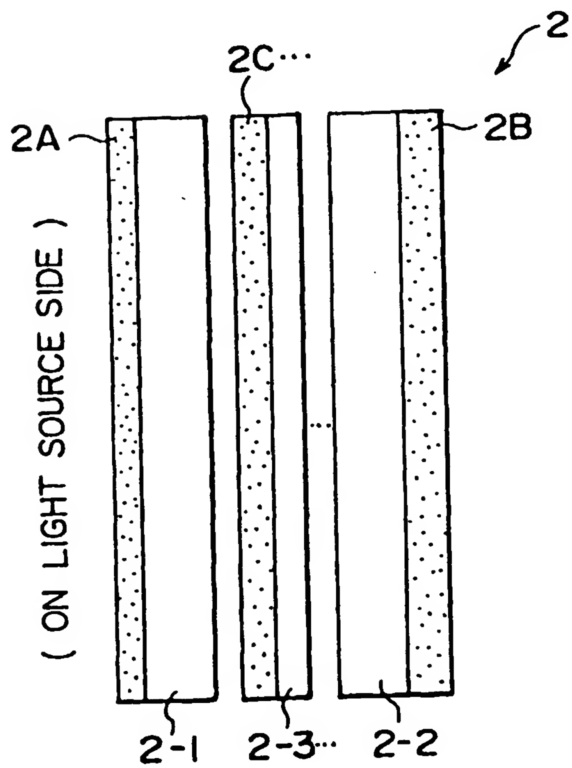
2. The rear projection screen according to claim 1, wherein one of the two or more diffusing parts is provided on a light-entering-side surface of the lens sheet, and another one of the diffusing parts is provided on a light-emerging-side surface of the lens sheet.

3. The rear projection screen according to claim 1, wherein the two or more diffusing parts are provided on a surface of the lens sheet and inside the same.

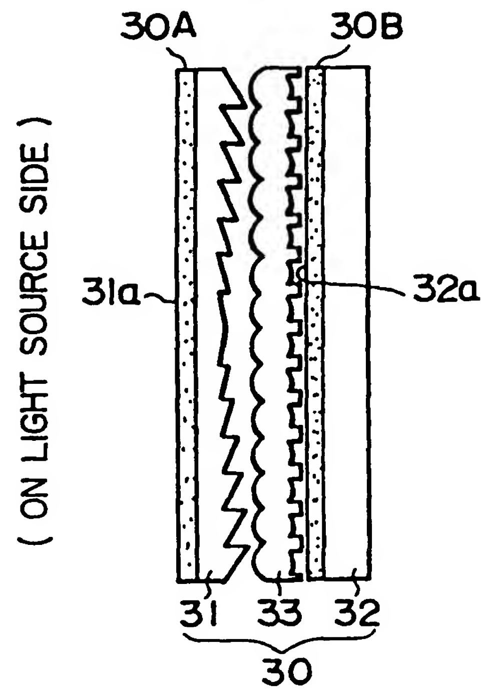
4. The rear projection screen according to claim 1, wherein any two of the two or more diffusing parts are such that a light-source-side diffusing part has a diffusing power lower than that of an observation-side diffusing part.


1C
1
1A
1B
(ON LIGHT SOURCE SIDE)

F I G. 1


2
2C···
2A
2B
(ON LIGHT SOURCE SIDE)
2-1
2-3···
2-2

F I G. 2


30A
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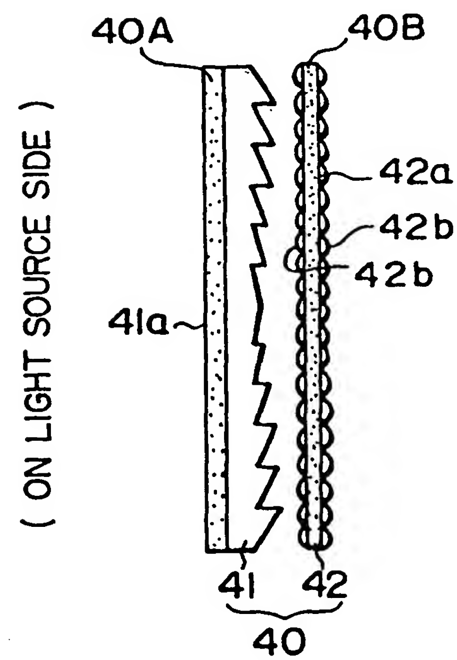
(ON LIGHT SOURCE SIDE)
31a
32a
31
33
32
30

F I G. 5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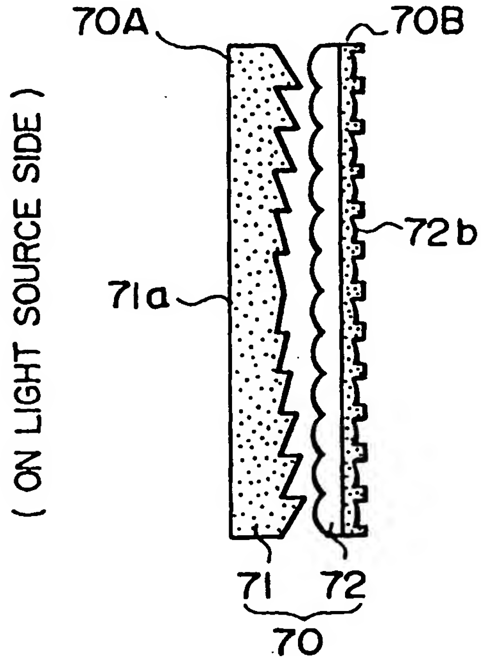
41
42
40

F I G. 6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71
72
70

FIG. 9A

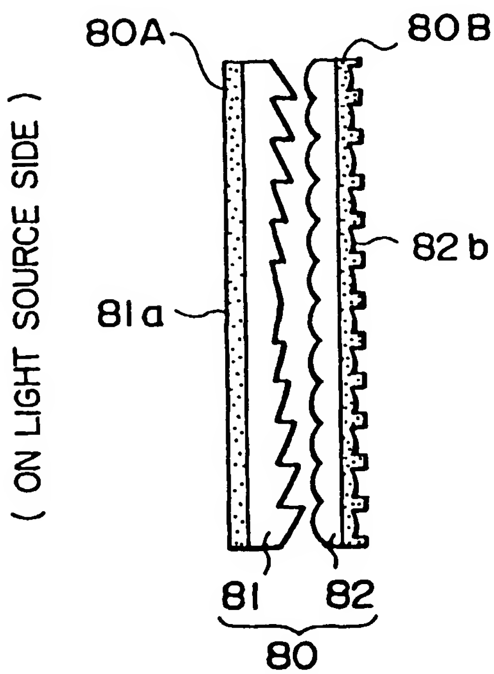
80A
80B
(ON LIGHT SOURCE SIDE)
82b
81a
81
82
80

FIG. 9B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP97/02546

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl[6] G03B21/62

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl[6] G03B21/62

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926 - 1997
Kokai Jitsuyo Shinan Koho	1971 - 1997
Toroku Jitsuyo Shinan Koho	1994 - 1997

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 8-15780, A (Kuraray Co., Ltd.), January 19, 1996 (19. 01. 96), Fig. 5 (Family: none)	1 - 12
P, X	JP, 9-114003, A (Toppan Printing Co., Ltd.), May 2, 1997 (02. 05. 97), Page 4, lines 3 to 7 (Family: none)	1 - 12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search October 21, 1997 (21. 10. 97)	Date of mailing of the international search report November 5, 1997 (05. 11. 97)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)